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Micromobility Adoption in an Urban Heritage City: Insights from Young Tourists in George Town, Penang

Irhanida Abdul Kadir[1,2]*, Woo Yee Nee[1]

[1] *School of Hospitality, Tourism and Culinary Arts, UOW Malaysia KDU Penang University College, 32, Anson Road, 10400, George Town, Penang, MALAYSIA*

[2] *School of Hospitality, Tourism and Culinary Arts, University of Wollongong Malaysia, Jalan Kontraktor U1/14, Glenpark U1, 40150 Shah Alam, Selangor, MALAYSIA*

*Corresponding Author: irhanida@uow.edu.my
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Abstract

As heritage urban centres face increasing challenges related to congestion, pollution, and accessibility, micromobility solutions have emerged as promising alternatives, particularly among younger demographics. This research employed a causal research design to assess the factors influencing micromobility adaptation among young tourists in George Town, Penang. Among the factors are perceived benefit, cost saving, environment motivation and perceived social norms. 200 sample size were used for this research. Data on socio-demographic characteristics were analysed descriptively, while the evaluation of the measurement model was done through multiple regression analysis. Findings from this study aimed to provide valuable insights for policymakers, urban planners, and micromobility service providers seeking to promote sustainable transportation solutions within heritage sites and urban environments. By understanding the unique needs and preferences of youngsters, strategies can be developed to enhance the accessibility, affordability, and attractiveness of micromobility options, thereby fostering more inclusive and environmentally sustainable transportation systems in George Town and other heritage cities. The results indicate that while perceived advantages do not notably affect the adoption of micromobility, factors such as cost savings, perceived social norms, and environmental motivation play a significant role. The study underscores the importance of overcoming obstacles to micromobility adoption and fostering environmental consciousness to facilitate the integration of micromobility into urban transportation systems. Additionally, policymakers can utilise these findings to develop focused approaches aimed at enhancing micromobility integration, thus promoting environmental sustainability and preserving cultural heritage in Penang.

1. Introduction

Micromobility within tourist destinations is viewed as an augmentation to the current transportation choices, facilitating improved access to primary tourist sites and, on a larger scale, aiding in alleviating congestion and mitigating negative environmental impacts (Davies et al., 2020). Research has yet to acknowledge micromobility as a standalone tourist attraction. Although conventional micromobility has been primarily viewed as a means of last-mile transportation, serving to connect transport hubs with final destinations, this perception needs to be re-evaluated in light of the proliferation of everyday micromobility devices (Jażdżewska-Gutta et al., 2023).

Micromobility is commonly defined as a category of low-speed, lightweight transport modes designed for short-distance urban travel, encompassing both human-powered and electrically assisted vehicles. These typically include bicycles, electric bicycles, e-scooters, and similar small personal transport devices used for first–last mile connectivity in urban transport systems. Gössling (2020) conceptualises micromobility as an evolving urban mobility domain that integrates both active transport modes and electric micro-vehicles, reflecting the broader transition toward electrified and shared mobility systems. In a complementary synthesis, O'Hern and Estgfaeller (2020) describe micromobility as a heterogeneous set of small personal mobility devices, including bicycles, e-scooters, and other emerging electric micro-vehicles, though they note that the exact boundaries of the category vary across policy and research contexts. Together, these perspectives highlight micromobility as a flexible and evolving classification rather than a fixed set of vehicle types. However, this study focuses solely on shared vehicles (those used by multiple individuals, either on a rental basis or through a peer-to-peer model). Specifically, the analysis considers bikes, e-bikes, mopeds, and e-scooters, as these are commonly utilised in the heritage cities.

Despite the growing body of research on micromobility, several important gaps remain. Existing studies have primarily focused on residents, commuters, and university students in urban settings, with particular emphasis on operational issues, travel behaviour, and technology adoption (Eccarius & Lu, 2020; Davies et al., 2020). While recent tourism studies have begun to explore tourists' use of shared mobility services, research examining micromobility adoption among tourists remains limited and fragmented, particularly within heritage city destinations where mobility choices are influenced by unique spatial, cultural, and environmental characteristics (Chen, 2025; Pojani et al., 2026). Furthermore, previous studies have largely concentrated on developed urban contexts, leaving a shortage of empirical evidence from Southeast Asian heritage cities such as George Town, Penang, where rapid tourism growth, narrow historic streets, and sustainability concerns create distinctive mobility challenges and opportunities. More importantly, limited attention has been given to the psychological and social determinants that shape young tourists' willingness to adopt micromobility in heritage destinations. As a result, there remains insufficient understanding of how perceived benefits, cost-saving considerations, social norms, and environmental motivations influence micromobility adoption among this increasingly important tourist segment. Addressing these gaps is essential for developing evidence-based policies and mobility strategies that support sustainable tourism and heritage conservation.

Young tourists represent a particularly relevant population for investigating micromobility adoption because they are generally more receptive to technological innovation, mobile applications, shared-economy services, and environmentally sustainable travel practices than older cohorts. Previous studies have shown that younger individuals exhibit stronger intentions to adopt shared micromobility services and are more likely to integrate these modes into their daily and leisure travel activities (Eccarius & Lu, 2020). Within tourism destinations, young travellers also tend to seek flexible, affordable, and experiential modes of transport that enhance destination exploration while reducing travel costs and environmental impacts. In heritage cities such as George Town, where walkability, congestion management, and heritage preservation are critical concerns, understanding the factors influencing young tourists' micromobility adoption is particularly important. As future consumers and advocates of sustainable mobility, their travel choices may significantly influence the long-term acceptance and diffusion of micromobility services in tourism destinations. Despite their importance, empirical research specifically examining young tourists' adoption of micromobility in heritage city contexts remains scarce. Therefore, investigating the behavioural determinants of micromobility adoption among young tourists can provide valuable insights for policymakers, tourism planners, and mobility service providers seeking to promote sustainable urban tourism.

The objectives of this research are:

- To investigate the relationship between perceived benefit and micromobility adaptation.
- To examine the relationship between cost saving and micromobility adaptation.
- To evaluate the relationship between perceived social norms and micromobility adaptation.
- To examine the relationship between environment motivation and micromobility adaptation.

Within the context of this study, the Theory of Planned Behaviour (TPB) is utilised to model the deliberate decision-making process involved in utilising micromobility. TPB has been widely employed across various fields, including travel behaviour research, as a framework for understanding human behaviour (Rozenkowska, 2023). Previous study has demonstrated the utility of this theory in explaining the underlying mechanisms of transport

J. Soc. Transform. Reg. Dev. Vol. 8 No. 1 (2026) p. 72-86

mode change and the acceptance of novel transportation modes such as shared mobility operations (Rozenkowska, 2023). The framework employed in this study incorporates four independent variables, namely perceived benefits, cost saving, perceived social norms, and environment motivation, which are the key factors of interest. The dependent variable, micromobility adaptation, is positioned on the right side of the framework. By examining the influence of perceived benefits, cost saving, perceived social norms, and environment motivation on young tourists, this study aims to provide new insights into their acceptance of micromobility adaptation in George Town, Penang.

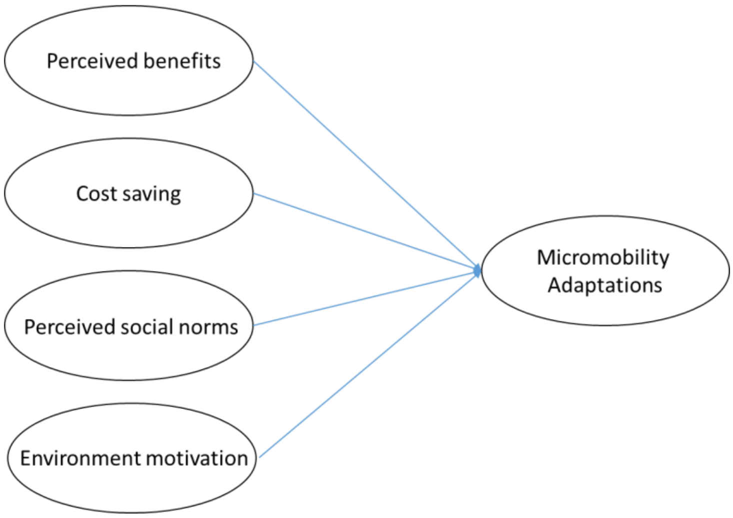

Fig. 1 *Research framework adopted from Shamsudin and Abu Hassim (2023)*

2. Literature Review

2.1 Micromobility Adaptation

The term "micromobility" is still a topic of discussion, but it generally refers to modes of transportation that don't involve motorised vehicles, such as walking and cycling, along with emerging forms of mobility. According to O'Hern & Estgfaeller (2020), electric bicycles (e-bikes) have experienced remarkable growth in recent years, particularly in China, Germany, and The Netherlands. E-scooters have also gained popularity as a new mode of transportation, especially in tourist cities. Davies et al. (2020), in their study on Chicago, propose that e-scooters are a cost-effective option for short-distance trips and have the potential to increase the number of households that do not rely on cars. While e-scooters and e-bikes cannot be categorized as non-motorized vehicles, they are considered a cleaner alternative to cars. Since short car trips contribute significantly to congestion and air pollution, these modes of transportation offer a compelling solution to these problems and can enhance the attractiveness of destinations.

The adaptation of micromobility in urban areas has been swift, with many people embracing it as a favored means of transportation. In recognition of the growing need for pedestrian and cycling infrastructure in cities and towns throughout the country, numerous local authorities are now considering micromobility as a viable alternative for short-distance travel and promoting active forms of transportation. A study in Penang, Malaysia, highlights the importance of outreach and factors influencing the choice of shared micromobility modes, as well as the modal shift from traditional travel modes (Shah, 2022). Shared micromobility is affordable for users and does not require huge infrastructure investments, making this innovative transportation technology a potential leapfrogging alternative in developing countries. It can serve as a standalone system or complement transit (Kadir et al., 2019).

The implementation of micromobility has the potential to be advantageous for city governments in terms of cost reduction. By relying on shared micromobility service providers to cover the expenses associated with offering and maintaining these convenient transportation options for first and last mile connectivity, governments can avoid spending significant amounts of money on transportation projects to extend these services to the public. Additionally, these micromobility services create employment opportunities within the gig economy.

Employment opportunities in the micromobility sector have also been identified within the broader platform economy. Prior research on gig work highlights that platform-based systems generate flexible and task-based employment structures, particularly in logistics, delivery, and urban mobility services (Wood et al., 2019; Cantarella & Strozzi, 2021). In the context of shared micromobility systems, operational tasks such as vehicle redistribution, charging, maintenance, and fleet balancing are typically carried out by distributed gig workers or contracted operators as part of fleet management strategies (Feng et al., 2020). These roles contribute to the operational efficiency of scooter-sharing systems by ensuring vehicle availability, safety compliance, and spatial redistribution in response to demand fluctuations. However, such work is often characterised by irregular income, algorithmic coordination, and task fragmentation typical of platform-mediated labour (Wood et al., 2019).

2.2 Perceived Benefits of Micromobility

The term "perceived benefit" refers to the positive consequences or outcomes that an individual believes will result from a specific behavior or action (Leung, 2013). Perceived benefits play a crucial role in influencing individuals' decisions to adapt to micromobility options. These perceived benefits can have a significant impact on the acceptance and adoption of micromobility as a preferred mode of transportation. Understanding these perceived benefits is important in promoting micromobility adaptation among different user groups. Perceived benefits includes environmental and personal benefits.

Firstly, the perceived environmental benefit is a major driver of micromobility adaptation. Previous studies consistently report that perceived benefits encourage micromobility adoption (Eccarius & Lu, 2020; Yasir et al., 2021). However, most evidence originates from developed urban contexts in Europe and China, where cycling infrastructure and environmental awareness are relatively mature. The applicability of these findings to heritage cities in developing countries remains uncertain. George Town presents a unique setting because tourism activities, heritage preservation requirements, and mixed transport systems may shape residents' perceptions differently. Consequently, further investigation is needed to determine whether perceived benefits remain a significant predictor of micromobility adaptation in this context.

Secondly, perceived personal benefits influence micromobility adaptation. Individuals often perceive micromobility as a means to improve their health and well-being. The incorporation of micromobility options in George Town encourages physical activity and active lifestyles among its residents. Cycling is associated with increased physical activity, improved fitness levels, and healthier lifestyles. Micromobility modes such as bicycles, e-bikes, and e-scooters also provide flexible, convenient, and cost-effective transportation alternatives for short-distance urban travel while complementing public transport systems (Şengül & Mostofi, 2021; Auchincloss et al., 2022; Hassam et al., 2024). Perceived personal benefits, such as increased physical activity, reduced travel time, and potential cost savings, contribute to the attractiveness of micromobility options and encourage their adoption (Turoń et al.,2021)

2.3 Cost Saving from Micromobility

Cost saving refers to the benefit realised from actions that reduce an organization's overall spending on assets that directly impact its bottom line (Eccarius & Lu, 2020). During purchase decisions, cost savings might be a key plan for E-bike adoption, as well as proof that customer satisfaction increases cost-saving psychology (Yasir et al., 2022). Micromobility adaptation in George Town, Penang can bring about significant cost savings for both individuals and the city as a whole.

Micromobility options such as bicycles, e-bikes, and e-scooters can provide a cost-effective alternative to private vehicle ownership, particularly for short urban trips. Compared with automobiles, micromobility users can avoid expenses associated with fuel consumption, parking charges, insurance, and vehicle maintenance. Furthermore, the lower acquisition and operating costs of micromobility vehicles make them an attractive transport option for students, young adults, and low-income users. As a result, regular use of micromobility can generate substantial long-term financial savings while improving transport accessibility and mobility choices (Kuhnimhof & Eisenmann, 2023; Şengül & Mostofi, 2021; Dias et al., 2022).

From a city perspective, promoting micromobility can lead to significant cost savings in terms of infrastructure development and maintenance. Compared to building and maintaining road networks to accommodate cars and motorcycles, the infrastructure required for micromobility is typically less extensive and costly. Implementing bike lanes, scooter parking areas, and pedestrian-friendly spaces can be a more cost-effective approach for urban planning. Additionally, micromobility options produce less wear and tear on roads and require less maintenance compared to larger vehicles, reducing the burden on city resources and budgets allocated for infrastructure maintenance and repair (Turoń et al.,2021).

2.4 Perceived Social Norms of Micromobility

Subjective norms are clarified by Yasir et al., (2022) as the perception of the society about adapting an alternative or selection for personnel use. Perceived social norms regarding micromobility can greatly influence individuals' decisions to adopt these modes of transport (Bretones et al.,2023). If micromobility is seen as socially acceptable and even desirable within the community, people are more likely to embrace it. Positive attitudes towards micromobility can be influenced by various factors such as peer influence, media representation, and cultural values. When individuals perceive that their friends, family, or other members of society view micromobility as a

J. Soc. Transform. Reg. Dev. Vol. 8 No. 1 (2026) p. 72-86

normal and respected form of transportation, they are more inclined to adopt it themselves (An et al., 2023). This perceived social acceptance creates a positive feedback loop, as increased adoption of micromobility further reinforces its social norm, making it more acceptable and accessible for others in the community (An et al., 2023).

Perceived social norms also play a role in promoting safe and responsible behavior in micromobility adaptation. When individuals observe others practicing safe riding habits, following traffic rules, and wearing appropriate safety gear while using micromobility modes, it establishes a normative behavior within the community (Basch et al., 2023). This can influence others to adhere to similar practices, creating a safer environment for micromobility users. Additionally, the perception of safety in numbers can emerge, where increased micromobility adaptation leads to a greater presence of cyclists, scooter riders, and pedestrians on the streets (Samsonova, 2021). This increased visibility can enhance the overall safety perception and encourage more individuals to engage in micromobility, knowing that they are part of a larger group of people practicing similar behaviors.

2.5 Environmental Benefits from Micromobility

Environmental motivation is defined as the motivation to care for the environment (Kühn & Bobeth, 2022). It involves individuals' conscious efforts to minimise the negative impact of human activities on the environment. Micromobility options offer a sustainable alternative to traditional modes of transportation, which heavily rely on fossil fuels and contribute to air pollution and carbon emissions. Environmental motivations drive individuals to choose micromobility as a means of reducing their carbon footprint and supporting a cleaner and greener environment. By utilising micromobility, individuals can actively contribute to the preservation of the city's natural surroundings and help combat climate change. The perception of micromobility as an environmentally friendly option encourages individuals to make conscious choices that align with their values and promote a sustainable lifestyle.

Awareness and education about the environmental impacts of transportation can motivate individuals to embrace micromobility in George Town. When people are informed about the detrimental effects of excessive car usage and the benefits of sustainable alternatives, they become more motivated to adopt micromobility options (Asensio et al., 2022). Efforts by local authorities, community organisations, and educational institutions to raise awareness about the importance of environmental preservation and the role of transportation in achieving sustainability goals can inspire and motivate individuals to choose micromobility (Abdelkareem et al., 2023). This environmental consciousness can lead to a collective sense of responsibility towards the well-being of the city and its natural resources, fostering a culture of micromobility adaptation (Samsonova, 2021).

(a) **(b)**

Fig. 2 *Figure description (a) Sharing bike facilities; (b) Micromobility lane in UNESCO heritage sites, George Town*

2.6 Theory of Planned Behaviour (TPB)

The present study is underpinned by the Theory of Planned Behaviour (TPB), which has been widely employed to explain and predict individuals' behavioural intentions and actual behaviours across various contexts, including transportation and sustainable mobility. TPB posits that behaviour is primarily influenced by behavioural intention, which in turn is determined by three key constructs: attitude toward the behaviour, subjective norm, and perceived behavioural control (Ajzen, 1991). Attitude refers to an individual's positive or negative evaluation of performing a particular behaviour, subjective norm reflects perceived social pressure from important others, and perceived behavioural control represents the perceived ease or difficulty of performing the behaviour based on available resources and opportunities (Ajzen, 1991).

TPB has been extensively applied in studies examining travel behaviour, active transportation, cycling adoption, and environmentally sustainable mobility choices. Research suggests that individuals are more likely to adopt sustainable transport modes when they perceive positive outcomes associated with their use, receive support from significant social groups, and believe they possess the necessary resources and opportunities to engage in the behaviour (Bamberg et al., 2003; Donald et al., 2014). Consequently, TPB provides a robust theoretical foundation for understanding the factors influencing micromobility adaptation in urban settings.

In the context of the present study, perceived benefits, cost saving, and environmental benefits represent belief-based evaluations that contribute to an individual's overall attitude toward micromobility. According to TPB, favourable attitudes are formed when individuals perceive that a behaviour generates desirable outcomes. Previous studies have shown that perceived convenience, flexibility, economic advantages, and environmental sustainability positively influence attitudes toward alternative transportation modes and increase the likelihood of their adoption (Kaplan et al., 2015; Fishman et al., 2013). Individuals who perceive micromobility as beneficial, affordable, and environmentally responsible are therefore expected to develop more favourable evaluations of its use.

Perceived social norms correspond directly to the TPB construct of subjective norm. Subjective norms reflect the influence of family members, friends, colleagues, and society on behavioural decision-making. In transportation research, social influence has been identified as an important determinant of sustainable mobility behaviour, particularly when individuals observe positive attitudes and support for alternative transport modes among their social networks (Bamberg et al., 2003; Chen & Chao, 2011). As micromobility becomes increasingly visible and socially accepted, individuals may feel greater encouragement to adopt these modes of transportation.

The dependent variable, micromobility adaptation, represents the behavioural outcome of interest. TPB suggests that favourable attitudes and supportive subjective norms increase the likelihood of behavioural adoption. In the case of micromobility, individuals who recognise personal and environmental benefits while receiving positive social reinforcement are more likely to integrate micromobility into their daily travel routines (Donald et al., 2014). Accordingly, TPB provides a suitable framework for examining how attitudinal and social factors influence micromobility adaptation in George Town.

The application of TPB is particularly relevant in George Town because the city faces increasing transportation challenges associated with urbanisation, tourism activities, and sustainability objectives. Although previous studies have examined sustainable mobility adoption in developed countries, evidence from heritage cities in developing countries remains limited. Therefore, applying TPB in the context of George Town contributes to extending understanding of micromobility adaptation within a unique urban and cultural environment. Table 1 is showing the mapping of study variables to TPB constructs: -

Table 1 *Mapping of study variables to TPB constructs*

Study variables	TPB Constructs
Perceived Benefits	Attitude toward Behaviour
Cost Saving	Attitude toward Behaviour
Environmental Benefits	Attitude toward Behaviour
Perceived Social Norms	Subjective Norm
Micromobility Adaptation	Behaviour

3. Research Methodology

3.1 Research Design

This study employed an explanatory research design with a causal framework to examine the determinants of micromobility adoption among young tourists in George Town, Penang. A mono-method quantitative approach was adopted, using a structured questionnaire survey to collect primary data. This approach is appropriate for testing hypothesised relationships among constructs in behavioural research, particularly where measurement is based on latent variables derived from established scales (Saunders & Kulchitsky, 2021). The explanatory design is suitable as the study aims to identify and quantify the influence of perceived benefits, cost savings, social norms, and environmental motivation on micromobility adoption behaviour.

J. Soc. Transform. Reg. Dev. Vol. 8 No. 1 (2026) p. 72-86

3.2 Sample Size and Sampling Technique

Data were collected from 200 young tourists aged 18 to 24 years between January and March 2024 in UNESCO Heritage Zone sites in George Town, Penang. The age classification of "youth" follows the United Nations definition of individuals aged 15–24 years (United Nations, 2019).

The sample size of 200 is considered adequate for multivariate statistical analysis, including factor analysis and regression modelling. Prior methodological literature suggests that a minimum sample size of 200 is generally acceptable for stable factor solutions, while larger samples improve estimation precision and generalisability (Ariya et al., 2020).

A non-probability purposive (judgmental) sampling technique was employed. This approach was selected because the study specifically targeted young tourists with direct exposure to micromobility services within an urban heritage tourism environment. Given the absence of a complete sampling frame of eligible tourists in the study area, probability sampling was not feasible in this field context. Purposive sampling is widely recognised in behavioural and tourism research as an appropriate strategy when participants must meet predefined criteria aligned with research objectives, particularly in situ studies conducted in dynamic, high-footfall tourism environments where population lists are unavailable and visitor flows are transient (Etikan et al., 2016).

3.3 Research Instruments

For the survey, a questionnaire comprising six sections was developed. The questionnaires were distributed around UNESCO Heritage Sites in George Town, Penang. The initial section included a brief cover letter explaining the survey's purpose and collecting socio-demographic information from the respondents. Sections two to six focused on gathering respondents' expectations regarding perceived benefits, cost savings, perceived social norms, environmental motivation, and micromobility adaptation. A five-point Likert scale ranging from "1=Strongly disagree" to "5=Strongly agree" was used in the questionnaire. This scale was deemed appropriate for evaluating the factors influencing micromobility adaptation and is known for its ease of construction, management, and acceptability (Ariya et al., 2020). Table 2 displays all the items utilised in this study to assess the factors influencing young Malaysians' micromobility adaptation. To ensure the validity of the measurement items, content validity, as well as pre-test to 30 samples was carried out before the full-scale data collection. To support the validity, reliability analysis was performed to all the constructs used in the research.

Table 2 *Measurement items*

Variables	Measuring Items	Reference
Perceived Benefits	Using micromobility options, such as e-scooters or bike-sharing, provides convenience and time-saving benefits for short-distance travel.	(Şimşekoğlu & Klöckner, 2019)
	I believe that using micromobility options positively impacts traffic congestion and reduces the burden on existing transportation infrastructure.	
	Using micromobility options promotes a healthier lifestyle and contributes to personal well-being through physical activity.	
	Positive social and environmental impacts, such as reduced pollution and carbon emissions, influence and motivate me to adopt micromobility options.	
Cost Saving	The cost savings associated with using micromobility options (e.g., reduced fuel expenses, parking fees) significantly influence my decision to adopt them.	(Şimşekoğlu & Klöckner, 2019)
	Financial benefits, such as reduced transportation expenses, is important in motivating me to consider adopting micromobility options.	
	I believe that using micromobility options can lead to significant cost savings compared to traditional transportation modes (e.g., private cars, taxis).	
	The affordability of micromobility options is a major factor in their widespread adoption.	
	The potential long-term savings, such as reduced maintenance and insurance costs, significantly influence me to adopt micromobility options.	

Variables	Measuring Items	Reference
Perceived Social Norms	The adoption of micromobility options, such as e-scooters or bike-sharing, is socially accepted and encouraged in my community. The perceptions of others (e.g., friends, family, colleagues) heavily influence me to consider adopting micromobility options. I believe using micromobility options aligns with the social norms and values of your community. There is a general perception in my community that using micromobility options is a responsible and sustainable choice. Positive social reinforcements (e.g., media campaigns, community events) significantly influence me to adopt micromobility options.	(Şimşekoğlu & Klöckner, 2019)
Environment Motivation	My concern for environmental sustainability strongly influences my decision to adopt micromobility options (e.g., e-scooters, bike-sharing) for short-distance travel. Potential reduction of carbon emissions and environmental impact associated with using micromobility options is important to me to consider their adoption. I believe that adopting micromobility options contributes to a greener environment and positively impacts the overall ecological balance. Using micromobility options aligns with my personal values and commitment to environmental conservation. Environmental awareness campaigns and initiatives significantly influence me to adopt micromobility options as part of my daily transportation choices.	(Şimşekoğlu & Klöckner, 2019)
Micromobility Adoption	I believe micromobility (e.g., electric scooters, bicycles) can contribute to reducing traffic congestion in George Town, Penang. The integration of dedicated micromobility infrastructure (e.g., bike lanes, scooter parking) is effective in promoting the use of micromobility options. I am confident about the safety of using micromobility options (e.g., accidents, collisions) compared to other modes of transportation. I am likely to adopt micromobility options (e.g., electric scooters, bicycles) as a regular means of transportation in my daily life.	(Şimşekoğlu & Klöckner, 2019)

3.4 Statistical Assumption Testing and Data Screening

Prior to hypothesis testing, data were screened for statistical assumptions relevant to multivariate analysis.

3.4.1 Statistical Assumption Testing and Data Screening

Multicollinearity was assessed using Variance Inflation Factor (VIF) and tolerance values to ensure independence among predictor variables in the regression model. According to Hair et al. (2019), VIF values below 5 and tolerance values above 0.20 indicate that multicollinearity is not a serious concern. Similarly, Myers (1990) suggests that high multicollinearity can inflate standard errors and reduce the reliability of coefficient estimates; therefore, diagnostic testing is essential prior to hypothesis testing.

3.4.2 Normality

The normality of data distribution was evaluated using skewness and kurtosis values. George and Mallery (2010) suggest that skewness values within ±2 and kurtosis values within ±7 are acceptable for assuming approximate normal distribution in social science research. Additionally, Kline (2016) notes that multivariate analyses such as regression and SEM are robust to moderate deviations from normality, particularly with sample sizes above 200.

3.4.3 Common Method Bias (CMB)

Since the study relied on self-reported survey data collected at a single point in time, potential common method bias (CMB) was assessed. Harman's single-factor test was conducted using exploratory factor analysis to determine whether a single factor accounted for the majority of variance. Podsakoff et al. (2003) recommend this procedure as a widely used diagnostic tool for detecting CMB in behavioural research. In addition to statistical testing, procedural remedies were applied during survey design, including ensuring respondent anonymity, using neutral wording, and reducing item ambiguity to minimise social desirability and evaluation apprehension bias (Podsakoff et al., 2003; Kock, 2015).

4. Results and Discussion of Findings

4.1 Profile of Respondents

The final analysis was based on 200 valid responses collected from young tourists aged 18–24 who visited the George Town UNESCO World Heritage Site. The sample was gender-balanced (50.5% female; 49.5% male) and predominantly came from Asia (79%), followed by Europe (9.5%), Australasia (8.5%), and other continent groups (3%). Most respondents were college students (83%), while 17% are working. This demographic structure is consistent with the study's focus on young adults, a cohort that is particularly relevant for emerging micromobility adoption patterns in heritage cities.

Instrument reliability and internal consistency were confirmed through Cronbach's alpha analysis. All constructs exceeded the recommended threshold of 0.70, indicating satisfactory reliability: perceived benefits ($\alpha = 0.798$), cost saving ($\alpha = 0.938$), perceived social norms ($\alpha = 0.899$), environmental motivation ($\alpha = 0.893$), and micromobility adaptation ($\alpha = 0.830$). Normality tests further demonstrated that skewness and kurtosis values for all constructs fell within acceptable ranges (±1.0), supporting the suitability of the data for parametric analysis and multiple linear regression.

4.2 Descriptive Analysis

Descriptive statistics indicate generally positive perceptions of micromobility among respondents. Perceived benefits recorded the highest mean score ($M = 3.963$), followed by environmental motivation ($M = 3.859$) and cost saving ($M = 3.881$). Perceived social norms yielded a comparatively lower mean ($M = 3.573$), suggesting moderate social endorsement of micromobility within respondents' communities. Micromobility adaptation itself achieved a mean score of 3.699, indicating a cautiously favourable intention toward adoption rather than strong behavioural commitment. These findings suggest that while young users recognise the advantages of micromobility, contextual and social conditions may shape their actual adoption decisions.

4.3 Regression Results

Multiple linear regression analysis was conducted to examine the influence of perceived benefits, cost saving, perceived social norms, and environmental motivation on micromobility adaptation. The overall model was statistically significant ($F = 107.442$, $p < 0.001$) and demonstrated strong explanatory power, with an R^2 value of 0.705. This indicates that approximately 70.5% of the variance in micromobility adaptation among youngsters can be explained by the four independent variables, underscoring the robustness of the proposed model.

Among the predictors, environmental motivation emerged as the strongest determinant of micromobility adaptation ($\beta = 0.441$, $p < 0.001$), followed by perceived social norms ($\beta = 0.322$, $p < 0.001$) and cost saving ($\beta = 0.168$, $p = 0.033$). In contrast, perceived benefits did not exhibit a statistically significant relationship with micromobility adaptation ($\beta = 0.025$, $p = 0.677$). Consequently, hypotheses related to cost saving, perceived social norms, and environmental motivation were supported, whereas the hypothesis concerning perceived benefits was not supported.

Table 3 *Results of hypothesis testing*

	Hypothesis	Results
H1	There is a relationship between perceived benefits and micromobility adaptation.	Not Supported
H2	There is a relationship between cost savings and micromobility adaptation.	Supported
H3	There is a relationship between perceived social norms and micromobility adaptation.	Supported
H4	There is a relationship between environments motivation and micromobility adaptation.	Supported

4.4 Discussion of Findings

4.4.1 Perceived Benefits and Micromobility Adaptation

Contrary to much of the existing literature, perceived benefits did not significantly influence micromobility adaptation among young tourists in George Town. This finding can be better understood through the lens of the Theory of Planned Behavior (TPB), which distinguishes between attitudes and actual behavioral intention, where contextual constraints may moderate attitudinal effects (Ajzen, 1991).

Although perceived benefits such as convenience, flexibility, and environmental friendliness are well-established drivers of micromobility adoption in urban settings (Shaheen & Cohen, 2019), their non-significance in this study suggests a potential ceiling effect or attitude saturation, where respondents already uniformly agree on benefits but do not translate them into behavioral intention due to external constraints.

In the specific context of a UNESCO heritage zone, structural and regulatory factors may override attitudinal determinants. George Town's narrow streets, mixed pedestrian-vehicle environments, and fragmented micromobility infrastructure may create perceived behavioral control limitations, weakening the predictive power of perceived benefits within TPB (Ajzen, 1991). This indicates that even when users cognitively acknowledge benefits, adoption is contingent upon perceived feasibility rather than perceived advantage alone. This also aligns with value-action gap theory, which argues that pro-environmental attitudes do not always translate into behavior when situational barriers exist (Blake, 1999). Hence, perceived benefits may function more as a baseline expectation rather than a differentiating factor in adoption decisions among young tourists.

4.4.2 Cost Saving as an Economic Driver

Cost saving significantly influenced micromobility adaptation, reinforcing the centrality of economic rationality in transport choice models, particularly within utility maximization frameworks (Becker, 1965). For young tourists, many of whom are students with constrained budgets, price sensitivity becomes a dominant decision-making heuristic.

From a behavioral economics perspective, micromobility may be evaluated through relative cost comparison, where its perceived affordability compared to ride-hailing, taxis, or vehicle rentals increases its attractiveness. This supports prior findings that cost is a critical determinant in shared mobility adoption, especially among younger cohorts (Shaheen & Cohen, 2019; Turoń et al., 2021).

In heritage cities like George Town, where transport infrastructure expansion is limited due to conservation policies, micromobility becomes not only an economic substitute but also a functional necessity for short-distance mobility, reinforcing its role as a practical rather than purely sustainable choice.

4.4.3 Role of Perceived Social Norms

Perceived social norms significantly influenced micromobility adaptation, highlighting the relevance of the Subjective Norm construct in TPB (Ajzen, 1991). This suggests that young tourists are strongly influenced by peer behaviors, social visibility, and perceived approval from their social environment.

In collectivist cultural contexts such as Malaysia, social influence tends to exert stronger behavioral pressure compared to individualistic settings (Hofstede, 2001). Therefore, micromobility adoption is not only an individual decision but also a socially embedded practice shaped by peer reinforcement and observational learning.

Furthermore, visible micromobility usage in public spaces may create a normative signaling effect, where adoption by some users increases perceived legitimacy and desirability among others. This aligns with diffusion of innovation theory, which emphasizes the role of social systems and early adopters in normalizing new technologies (Rogers, 2003).

4.4.4 Role Environmental Motivation and Sustainability Orientation

Environmental motivation emerged as the strongest predictor of micromobility adaptation, indicating that adoption behavior is strongly aligned with pro-environmental value systems. This finding is consistent with the Value-Belief-Norm (VBN) theory, which posits that personal norms and environmental values directly influence pro-environmental behavior (Stern, 2000).

In the context of George Town UNESCO World Heritage Site, environmental awareness may be further amplified by the symbolic meaning of preservation and sustainability embedded in heritage conservation discourse. Thus, micromobility adoption becomes a form of identity-consistent behavior, where individuals' express environmental responsibility through transport choices.

This result also supports prior empirical studies showing that environmental concern is a strong predictor of micromobility adoption, particularly among younger demographics who exhibit higher sustainability awareness (Fishman, 2016; Shaheen & Cohen, 2019). Importantly, environmental motivation may function not only as a

J. Soc. Transform. Reg. Dev. Vol. 8 No. 1 (2026) p. 72-86

direct predictor but also as a mediating value dimension, reinforcing both normative and behavioral intentions in sustainable mobility contexts.

5. Novelty and Contribution of the Study

The primary novelty of this study lies in its empirical examination of micromobility adaptation within a UNESCO World Heritage Site from a youth-centric perspective. Unlike prior studies that emphasise functional or technological benefits, this research demonstrates that value-based factors, particularly environmental motivation and social norms, outweigh perceived benefits in influencing adoption intentions. The non-significant role of perceived benefits challenges conventional assumptions in micromobility research and suggests that in heritage contexts, behavioural adaptation is shaped more by socio-cultural and normative factors than by instrumental advantages alone. By integrating the Theory of Planned Behaviour into a heritage-city setting, this study extends micromobility literature beyond generic urban environments and contributes nuanced insights relevant to sustainable tourism and heritage management. The findings offer practical implications for policymakers and urban planners, highlighting the need to complement infrastructure provision with social norm activation and environmental advocacy to foster micromobility adoption among young users in culturally sensitive urban landscapes.

6. Limitations and Recommendations for Future Studies

This research sheds theoretical light on the independent variable influencing micromobility adaptation among youngster in Georgetown UNESCO heritage, Penang. However, there are still several limitations to the study. Firstly, the main limitation of the study is the age range of the respondents. Since the main target respondents of this study is youngsters in Malaysia, according to the United Nation (2019) only respondents between 15 to 24 years old are eligible for the study. According to Chen (2025), the segregation of different age group can affect the micromobility adaptation expectations. Therefore, future research can include a wider sample to be more representative of Penang citizens from other age groups, such as middle-aged adults, which could help the ministry of transportation compare the relationship between perceived benefit, cost saving, perceived social norms, environment motivation and micromobility adaptation.

Furthermore, the second limitation of this study is the nationality of the respondents. The title of this study shows that only Malaysians are considered in this research, people from other countries are not eligible. To better understand the citizen expectations and willingness to micromobility adaptation in the hospitality industry. Future research on micromobility adoption in the hospitality sector in Malaysia could explore the experiences of foreigners, including tourists. Their distinct expectations and transportation needs could offer valuable insights into the implementation of micromobility solutions, not only in Malaysia but also in other nations.

Thirdly, this study is subject to sampling bias. The use of non-probability or convenience sampling (if applicable in your study design) may lead to overrepresentation of certain demographic groups (e.g., students or digitally connected youth), thereby limiting the representativeness of the findings. Sampling bias can systematically distort observed relationships between constructs and reduce external validity (Etikan et al., 2016). Future studies should consider probability-based sampling techniques, such as stratified or cluster sampling, to improve population representativeness and robustness of findings.

Fourthly, the research relies on self-reported survey data, which introduces potential limitations such as social desirability bias, recall bias, and common method variance. Respondents may overstate environmentally friendly attitudes or underreport barriers such as safety concerns. Self-reported behavioural intention does not always accurately reflect actual behaviour in mobility studies (Podsakoff et al., 2003). Future research should therefore integrate objective behavioural data (e.g., GPS tracking, app usage logs, or travel diaries) or adopt mixed-method approaches to improve data validity.

On the other hand, the conceptual model in this study focuses on perceived benefit, cost saving, perceived social norms, and environmental motivation. While these factors provide a useful foundation, they do not fully capture the complexity of micromobility adoption. Future research should extend the model by incorporating additional determinants such as accessibility, digital literacy, infrastructure availability, and perceived safety risk. Accessibility is particularly important in shaping the ease of use and availability of micromobility options in dense urban heritage environments. Similarly, safety perception and infrastructure quality significantly influence user trust and willingness to adopt shared mobility systems (Shaheen & Cohen, 2020). Investigating these factors would provide a more comprehensive understanding of adoption behaviour and inform more effective policy and urban planning interventions.

Finally, future studies could also explore the role of educational background and prior exposure to micromobility systems. Differences in knowledge and experience may moderate adoption behaviour and perception formation, offering further insight into user heterogeneity in emerging mobility systems.

7. Conclusions and Recommendation

All in all, this study provides an empirical examination of the relationships between perceived benefit, cost saving, perceived social norms, environmental motivation, and micromobility adaptation among young users in George Town, Penang. The findings indicate that perceived benefits do not have a statistically significant effect on micromobility adaptation ($p > 0.05$), suggesting that functional advantages alone may not be sufficient to drive adoption in this context.

The results further suggest the presence of contextual barriers to micromobility uptake, including limited access, skill-related constraints, and safety concerns. These findings are consistent with prior research indicating that perceived risk, infrastructure readiness, and usability constraints can significantly shape micromobility adoption decisions in urban environments (Shaheen & Cohen, 2020; Reck et al., 2021). Addressing these barriers remains important for improving the feasibility of micromobility as part of sustainable urban transport systems.

Conversely, cost saving, perceived social norms, and environmental motivation were found to have statistically significant positive relationships with micromobility adaptation. This suggests that economic considerations, social influence, and environmental awareness play more influential roles than perceived functional benefits in shaping adoption behaviour among the sampled respondents. However, given the non-probability sampling approach and the geographic limitation to young respondents in George Town, these findings should be interpreted as context-specific rather than broadly generalisable to the wider youth population in Penang or other heritage cities.

In particular, the significance of perceived social norms highlights the role of peer influence and collective behavioural expectations in shaping sustainable mobility choices, while environmental motivation reflects increasing awareness of sustainability issues among urban youth. These findings align with prior studies emphasising the importance of normative and environmental drivers in sustainable transport adoption (Kahn, 2007; de Nazelle et al., 2011).

Overall, while the findings provide useful insights for understanding micromobility behaviour within the study context, caution should be exercised in generalising the results due to the sampling method and scope limitations. Future research using larger, probability-based samples across multiple heritage cities would help strengthen the external validity of these findings and further refine policy implications for micromobility integration in urban transport systems.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Irhanida Abdul Kadir, Woo Yee Nee;* ***data collection:*** *Woo Yee Nee;* ***analysis and interpretation of results:*** *Irhanida Abdul Kadir, Woo Yee Nee;* ***draft manuscript preparation:*** *Irhanida Abdul Kadir. All authors reviewed the results and approved the final version of the manuscript.*

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